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THE NEED FOR SYSTEM ANALYSIS BASED ON TWO STRUCTURED ANALYSIS METHODS SADT AND SA/RT

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Abstract: The aim of this paper is to present the need for two methods of system analysis. The first method is the Structured Analysis Design Technique (SADT) method used in designing computer integrated manufacturing systems. The second method is the Structured Analysis for Real Time (SA/RT) method that consists in putting in evidence inside data flow diagrams elements dedicated to the control view. Then, we present a review on the two methods SADT and SA/RT and their applicability in the industrial and pedagogical fields. Thus, some applications of the SADT and SA/RT methods that have been presented in various researches are presented. Previous researches showed that any kind of system can be modeled using structured methods.
Keywords: System analysis; SADT method; SA/RT method; domain modeling

INTRODUCTION

Early in the system design process, a variety of a design method is usually dictated by what methods the designer has earlier used, not by an open selection process. In fact, particular interest in the use of graphical modeling methods and techniques to aid changes in system operations and the interactions of staff to effectively build and use modelling for analysis, design and communication of systems in the manufacturing industry.

Besides systems specification supposes two essential characteristics: temporal evolution of the system components and the system - environment interaction. Indeed, the complexity of relations between a system and its environment is especially verified in the domain of process conduct.

Among the techniques of system specification, we mention: (1) methods of analysis that permit to systematize and to canalize the various perceptions, (2) specification languages possessing syntax and very definite semantics, and (3) simulation languages.

Structured Analysis Design Technique (SADT), which was designed by Ross in the 1970s [1-3], was originally designed for software engineering but quickly additional areas of application were found, such as aeronautic, production management, etc.

SADT is a standard tool used in designing computer integrated manufacturing systems [4-6]. In fact, a significant complexity of automated manufacturing systems requires methods and tools which must allow preliminary safety analysis beginning right from the start of the design cycle [5].

In order to present how SADT is a proven design method, we present some researches in this paper: (1) the extended SADT method with respect to timing constraints and formalization, (2) the Safe-SADT method for dependability evaluation and (3) the augmentation approach for software development methods.

This paper can be loosely divided into six parts: First, we present the SADT method and second, we present the SA/RT method. In section three, we present a review on SADT and SA/RT and their applicability in the industrial fields. Then, we present some researches to augment the SADT method in order to take into account the timing constraints, the formalization and the dependability evaluation. Then, we present how structured analysis augments software development methods. Finally, the last section presents conclusion and future work.

PRESENTATION OF THE SADT METHOD

As the inventor of SADT, Ross was an early developer of structured analysis methods. Through the 1970s, along with other contributors from SofTech, Inc., Ross helped develop SADT into the IDEF0 (Icam DEFinition for Function Modeling) method for the Air Force's Integrated Computer-Aided Manufacturing (ICAM) program's IDEF group of analysis and design methods [7].

Although SADT does not require any specific supporting tools, several computer programs implementing SADT methodology have been developed. In fact, IDEF0, a function modeling building on SADT, is designed to characterize the decisions, actions and activities of an existing or prospective organization or system [8].

IDEF0 graphics and accompanying texts are presented in an organized and systematic way to gain understanding, support analysis, provide logic for potential changes, specify requirements and support system-level design and integration activities. IDEF0 may be used to model a wide variety of systems, composed of people, machines, materials, computers and information of all varieties, and structured by the relationships among them, both automated and non-automated.

For new systems, IDEF0 may be used first to describe requirements and to specify the functions to be carried out by the future system. As the basis of this architecture, IDEF0 may then be used to design an implementation that meets these requirements and performs these functions. For existing systems, IDEF0 can be used to analyze the functions that the system performs and to record the means by which these are done.

Figure 1 shows the Top-down, modular and hierarchical decomposition of SADT.

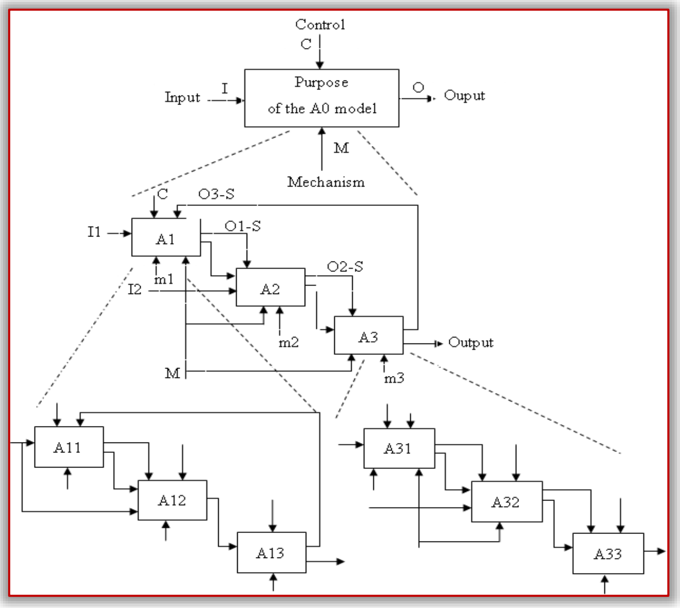

Figure 1. SADT method

The boxes called ICOM's input-control-output-mechanisms are hierarchically decomposed. At the top of the hierarchy, the overall purpose of the system is shown, which is then decomposed into components-subactivities. The decomposition process continues until there is sufficient detail to serve the purpose of the model builder. SADT/IDEF0 models ensure consistency of the overall modelled system at each level of the decomposition.

Unfortunately, they are static, i.e. they exclusively represent system activities and their interrelationships, but they do not show directly logical and time dependencies between them. SADT defines an activation as the way a function operates when it is 'triggered' by the arrival of some of its controls and inputs to generate some of its outputs. Thus, for any particular activation, not all possible controls and inputs are used and not all possible outputs are produced. Activation rules are made up of a box number, a unique activation identifier, preconditions and postconditions.

Preconditions and postconditions describe what is required for and what results from the activation. Both preconditions and postconditions are logical expressions of ICOM codes, where each ICOM code identifies a single control, input, output, or mechanism arrow for that particular box. When an ICOM arrow does not participate in activation, it is simply omitted from the precondition. Similarly, when some of the outputs of a box are produced during activation, the ICOM codes for those outputs not generated are omitted from the postcondition. A precondition expresses the required presence (or absence) of any of the objects associated with the inputs, controls, outputs, or mechanisms involved in the activity. A post condition indicates presence (or absence) after the activity has occurred.

In the following paragraph, we present the extended SADT with respect to timing constraints and formalization and a Safe-SADT method for dependability studies.

Extended SADT

There are many method used for representing the processes and the activities: one of the most known is the SADT method. In fact, this formalism adopts a static modeling of the process which is a chain of activities destined to understand, specify and do organization diagnosis. Furthermore, this formalism doesn't permit simulation for estimation purposes that need the data and temporal introduction.

Researcher Feller A. and Rucker R. [9], has proposed an extended SADT method and has described the need for such a method more than 30 years ago. This extended SADT method has been used in many applications with respect to timing constraints and formalization. One of these applications is a proposal of a gait of a physical and economic performance analysis.

However, the main adaptation that the Researcher has brought to the extended SADT formalism on the control arc that he thinks it more generally as a secondary input flow not necessarily intended to control the activity, this function can be provided by the trigger arc.

Safe-SADT

Dependability evaluation is a fundamental step in automated system design. However, the current dependability evaluation methods are not appropriate given the level of complexity of such systems. Given the ineffectiveness of the current methods, Researcher Bernard V. [10] has proposed the Safe-SADT formalism for dependability evaluation, an extension of the SADT method.

In this section, we present briefly in one hand the Safe-SADT model and in other hand, we show its applicability in industrial fields through two case study. In fact, dependability evaluation is crucial to controlling the risks associated with system failure, and for this reason, it is one of the fundamental steps in automated system design [11].

Indeed, the Safe-SADT approach deals progressively with complexity. Top-down and hierarchical, it focuses on the functions that the system must achieve through function entities and material entities. First, the system is described generally, and then the details are embedded as the analysis progresses. A Safe-SADT model is organized hierarchically.

At the top level, the system is summarized with a single global block A0. This block can be broken down at a lower level with more blocks that contain more information on the subsystems. This lower-level decomposition is performed until the parts that make up the overall system are listed (e.g., material entities within the operational architecture, which are specified at the bottom of a Safe-SADT block).

The advantage of this formalism is that it allows the formalization of functional interactions by integrating dependability parameters]. The Safe-SADT approach provides a block representation to graphically define complex systems in terms of functional requirement specifications (FRS).

Thus, the formalism allows complex systems to be described in terms of systems, subsystems, and the relationships between subsystems. Each system decomposition is defined with a Safe-SADT block with the objectives of clearly specifying the input functions, output functions, and material entities executing the input functions under some constraints.

By means of significant example, Researchers, Cauffriez L. & al. [12], have presented a study on the use of field buses combined with intelligent sensors and actuators which are opening up new possibilities for building control systems. If field buses seem to be a good solution to improve the dependability, it could be also a trap due to the new possible failures they may introduce. They have studied these failures and their effects on dependability parameters. Some elements are presented in order to provide designers with means to assess dependability at each design step by integrating field feedback. Assessing dependability is too often limited to an evaluation at the end of the design process, which often involves reselecting previous choices. To sum up, this contribution constitutes a structured overview of field bus faults given to help users to select the most suitable field bus for their applications, both in control and measurement.

Researchers, Cauffriez L. & al. [13], have presented a computer-aided design tool software for modeling and comparing several architecture design choices early on in the design process. Its originality is based on operational architecture composed of function entities executed by material entities. A Monte Carlo approach allows simulation of "possible life history" and points out design's weaknesses using sensitivity analysis. The researchers have illustrated the tool functionalities with a temperature system. Possibilities for future research in terms of software development and industrial applications are provided.

PRESENTATION OF THE SA/RT METHOD

The SA/RT (Structured Analysis for Real-Time Systems) method was defined in the mid 80's by two research teams: Ward and Mellor [14], Hatley and Pirbhai [15]. Their works, carried out separately, propose real-time extensions of DeMarco's structured analysis. The extensions concern the addition of the control functionalities describing the dynamics of the system and the corresponding data processing [16].

The basic idea of this graphical method consists in putting in evidence inside data flow diagrams elements dedicated to the control view. A data flow diagram (DFD) provides a processes (activities) net drawing. A DFD expresses a representation means to depict inter-processes exchanges, in order to enlighten the control or data flows sent or received by each process when an execution is performed. Consequently, such a diagram shows a special activity whose role is to pilot the set of other activities. This control activity study is therefore tackled to describe the effective control logic [17].

Figure 2 shows the representation principles of the functional, the behavioral and the informational view of a system by means of the SA/RT method.

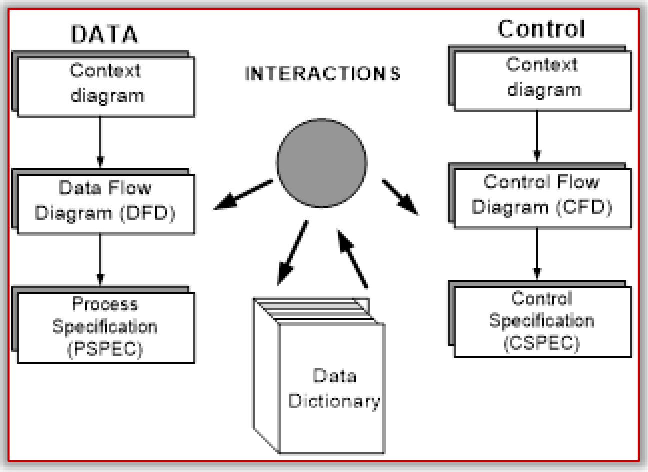

Figure 2. SA/RT method

The functional view of SA/RT method is modeled by means of the structured analysis tools. The graphic components of the model are data flows, data storages and processes. They are organized by means of specific construction rules into diagrams named Data Flow Diagrams (DFD). The first DFD is the context diagram. It gives the only system representation inside which are visualized the model borders. They define the limit between the system and its environment. The model is organized as a hierarchy of DFD, whose context diagram represents the highest level. Each DFD expresses a refinement of one immediate ancestor DFD such that the decomposed process is called father process of one of its son processes. At the bottom of the branching, the leaves identify atomic processes. Also called primitive, those processes cannot be described through DFD; we have to resort to another representation mode. This ultimate step of the functional modeling corresponds to the process specification (PSPEC) which is mainly done using textual languages.

- Informational aspect of the SA/RT method: The data and the events occurring at all the model stages are defined in a dictionary. As for the complex data storage, the WM approach predicts a modeling by means of Entity/Association diagrams used for modeling sizeable and complex data such as databases.
- The behavioral view of SA/RT: this aspect of the studied system is supported by tools which are able to take into account events needed to manage correct process execution. A control model is derived for each DFD drawn and supplies the control logic to be applied to their related sub-processes. So the control logic hierarchy is established upon the DFDs one. Each control unit specification is realized using automaton, or state transition table or array.
- SA-RT is the specification models that have been widely used in real-time system and software engineering applications. It is a generic method addressing both

system analysis and the design of real-time and complex systems.

- SA/RT diagrams deal with two views of the considered system: a static view, the structural description, and a dynamic view, the behavioral description. In SA/RT standards (though slightly different), the structural description is done by data flow diagrams (DFD) and the behavioral description is done by the control flow diagram (CFD) coupled with state transition diagrams (and/or process activation tables). For SA/RT specifications other tools are also used (including process specifications, data dictionary...) which are mainly textual tools.

REVIEW ON THE SADT AND SART METHODS

This section presents some studies of the SADT method and its applicability in the industrial and pedagogical fields that have been presented in various researches:

Researchers, Lezina, O.V. and Akhterov A.V. [18], have presented the structure of information component of pedagogical knowledge management system in the chair of technical university and the possibility of using the ontologies and SADT methodology for the design of information component of such system. In fact, the modern stage of social development, the emergence of the knowledge based economy; the rapid dissemination of educational information and telecommunication technologies, as well as modernization of the system of higher education makes new requirements to preparation of graduates. This requirement necessitates the need to create and use of flexible pedagogical knowledge management system.

Researchers, Yulian C. & al. [19], have investigated and analyzed the production workflow in small and medium toy manufacturing enterprises by SADT and simulation analysis. They find out that tracking information is incomplete and information flow and material flow are out-sync due to lacking material and production process collaboration in current system. Thus, the tracking objective creates a need for systems to collaborate material flow and production flow in manufacturing enterprises. In fact, material safety and traceability is of great importance in toy manufacturing because there have been tougher requirements on toy product safety imposed by new international regulations.

Researchers, Demri A. & al. [20], have proposed to employ SADT, FMEA, SEEA and Petri networks methods to study a mechatronic system. In fact, a study of system reliability is generally preceded by a functional analysis, which consists of defining the material limits, the various functions and operations realized by the system and the various configurations. This stage does not give information about the modes of failure and their effects. It is necessary to complete it by a second one taking into account the dysfunctions in order to model suitably a complex system with Petri networks.

Researchers, Plateaux R. & al. [21], have proposed to integrate the entire downward side of the design V-cycle in order to achieve to a modelling continuity through the different levels of design approach (requirements, functional, components and structural). For this, they have proposed a hybrid methodology based on several tools, languages and methodologies such as SADT, SysML, Modelica, in a single environment: Dymola.

Researchers, Wenan T. & al. [22], have proposed respectively SADT-based e-learning process architecture and an SOA-based knowledge management mechanism. After that, they have discussed the process management model of e-learning from an overall lifecycle perspective. At last, the corresponding knowledge management architecture is presented to further support this process management.

Researchers, Yahmadi R. & al. [23], have presented a degradation analysis of the lead acid battery plate during the manufacturing process. The different steps of the manufacturing process of plate such as manufacturing of lead oxide, paste mixing and manufacturing of grid, pasting, curing and drying are describe d by SADT. The general analysis of all the causes and potential factors causing a low quality of the plate during the manufacturing process is created by the Ishikawa diagram. This description is completed by the Causal Tree Analysis in order to seek the various possible combinations of events leading to the low quality of lead acid battery plate during the pasting, curing and drying process.

Researchers, Zenniz Y. & al. [24], have presented the dependability of an automatic detection and extinction system with Halon. The risk control and analysis is done using three analysis methods, SADT, FMEA and FTA. The objective of the research is dependability planning optimization with the identification of the potential risks and these consequences on system. The optimal recommendations must be proposed. Decision tools used to improve production will be proposed. To achieve these objectives a detailed description of process structure and the main principles of both methods are given. These methods are applied on the system with a comparative study between the results given by these methods.

Researchers, Puilk E. & al. [25], have developed Reconfigurable Manufacturing Systems (RMS). With their modular structure, they can be integrated in a short period of time. Though this leaves more time for product development, it does not exclude the industrialization risks. Since configuration of equipment only works reliably if its process technology is well understood, it is needed that poorly functioning manufacturing processes are detected and addressed in an early stage. Only then, sufficient time is available for corrective actions to be taken. This paper presents a scientific framework to model the development of RMS. The method has the capability to uncover manufacturing risks during early development. In combination with RMS, the freeze of system architecture can indeed be pushed backwards in time. The method uses the SADT. The process risks, as outcome of the analysis process, are ranked using a FMEA to determine the severity of their impact.

Researchers, Jimenez F. & al. [26], have developed models and tools for system design and synthesis of MEMS-micro based on SDL (specification description language), SA-RT and PNs. In fact, a main problem concerns the design of these varied circuits because it associates disciplines such as electronics, mechanics, chemistry, etc.

DOMAIN MODELLING STRUCTURED ANALYSIS METHODS

The domain modeling can bring correct and complete context to today's software development methods. In fact, SADT has over 35 years of domain modeling experience, across a vast number of problems involving systems ranging from tiny to huge, in a wide variety of industries [27].

Indeed, SADT is a proven way to model any kind of domain. Its power and rigor come from:

1) a synthesis of graphics, natural language, hierarchical decomposition, and relative context coding,
2) distinguishing controls from transformations,
3) function activation rules, and
4) heuristics for managing model complexity [4].

Furthermore, domain modeling is at the core of SADT, and when properly used, the method can produces holistic domain models that can address any level of complexity or abstraction. Thus, SADT can produce a set of very concise, small models, with tightly connected context and content.

The distinguishing, unique aspect of SADT is its ability to holistically describe an entire domain to any desired low level of detail, and to describe its context to any desired high level of abstraction. It is thus, SADT and SART have an extremely simple graphic language and a model creation technique that, from the same starting point of any particular subject, can describe:

1) all details (i.e. decompose complexity),
2) the context of that subject (i.e. context modeling).

CONCLUSIONS

In this paper, we have presented a research on two different methods of structured analysis which are SADT and SA/RT. Then, we presented a review on this kind of structured analysis used to software development methods by using SADT and SA/RT.

Since context preservation is crucial for domain modeling, SADT and SA/RT have merit for augmenting the software development methods. In fact, three of its core features are: context, model, and viewpoint. Not only can SADT and SA/RT correctly, comprehensively and consistently describe an entire domain and not just the immediate context of a software system, it can describe that domain in rich and varied ways using carefully designed in-context supplements. Moreover SADT and SA/RT methods have been invented for general purpose domain modeling. In fact, a set of graphical diagrams and supplements that correctly and completely describe the domain. So, an approach has been taken to providing benefits to software development methods by using SADT and SA/RT.

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